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Sustainable Transition of Electric Two-Wheeler Vehicle (E2w) For Urban Dwellers

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Abstract
Electric Vehicles (EVs) are a promising solution to the environmental impact of fossil fuels and vehicle pollution. They offer an excellent alternative for commuting with zero environmental impact, especially given the scarcity of natural resources and rising fuel prices. E-vehicles support green energy and significantly reduce pollution. Effective marketing is needed to raise awareness of their benefits and motivate consumer adoption. This study aims to explore consumer perceptions and intentions towards Electric 2-wheeler vehicle (herein after referred as E2W or Electric Vehicle) adoption. In India, adopting electric vehicles (EVs) is essential for fuel saving, zero carbon dioxide emissions, and promoting green energy. However, meeting customer expectations and providing high-quality EVs is challenging. Despite the need to consider existing products and demand, EVs still represent only a small fraction of total vehicle sales in the country.

Keywords: *Electric Vehicles, Environmental impact, Fossil fuels, Vehicle pollution, zero environmental impact, green energy, Pollution reduction, Consumer, Fuel saving, zero carbon emissions.*

1. Introduction
Fossil fuels are the primary energy source globally, leading to significant greenhouse gas emissions and climate change (Gahlaut et al., 2024; Kamran et al., 2021). The transportation sector contributes 23% of global emissions, expected to rise to 50% by 2030 (Jaiswal et al., 2021) [1]. This indicates the need for significant changes to reduce the environmental impact of the transportation system (Egbue & Long, 2012). Urbanization and increased car usage, especially in new-economy countries like India, are major factors influencing the automobile industry's growth, posing various challenges. [2 In India, road travel is predominant, with 64.4% of goods and 90% of passengers using roadways (Ministry of Road Transport and Highways). The growing demand for vehicles has expanded the automobile industry, but it also generates various pollutants. Electric vehicles (EVs) offer a solution to reduce pollution and are gaining popularity worldwide [2]. The current requirements focus on fuel saving, zero carbon dioxide emissions, and adopting green energy through electric vehicles (EVs) [3]. In India, meeting customer expectations and providing high-quality EVs is challenging, as they still represent a small fraction of total vehicle sales. The Indian government has taken several steps to promote EVs, including initiatives in the 2025 budget by Finance Minister Nirmala Sitharaman to make India a global EV manufacturing hub [4]. This study aims to identify factors influencing the purchase decision of electric cars. The Indian government aims to have only electric vehicles (EVs) on the road by 2030 and is promoting hybrid and electric vehicle sales. Initiatives include tax deductions for loans used to purchase battery electric vehicles (BEVs) and the establishment of incubation centers for BEV start-ups. Despite these efforts, BEV adoption was only 1% in 2020 [5]. The industry is gradually shifting from internal combustion engines to EVs, which are more energy-efficient, emit fewer greenhouse gases,

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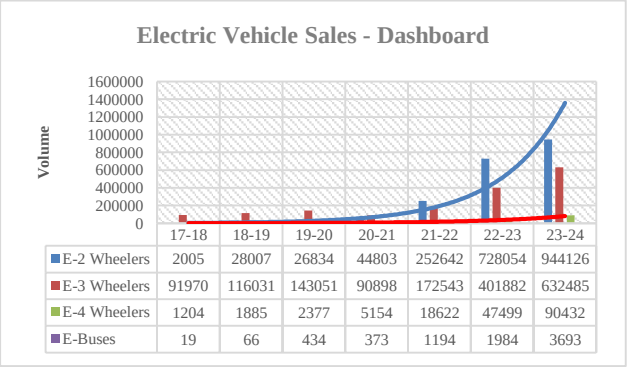
and produce less noise. Electric vehicles (EVs) have become a cleaner and more efficient alternative to gasoline-powered cars. With advancements in battery technology, a growing charging infrastructure, and increasing consumer demand, EVs are now a viable option for many drivers worldwide. Powered by electricity stored in batteries and using electric motors, EVs are changing the way we think about driving [6]. India, the third largest automobile market globally, is pushing for greener options. The automotive sector contributes 7.1% to India's GDP and provides significant employment. The Economic Survey 2023 predicts a 49% CAGR for the domestic electric vehicle market from 2022 to 2030, with 10 million annual sales by 2030. The EV industry is also expected to create around 50 million direct and indirect jobs by 2030. The Indian government aims to achieve 30% electrification of the vehicle fleet by 2030, introducing incentives and policies to support EV growth [7]. The FY24 Union Budget boosted the industry by promoting electric vehicle production, hydrogen fuel adoption, and new technologies. In the 2024-25 Union Budget, Finance Minister Nirmala Sitharaman allocated INR 35,000 crore for capital investments to achieve energy transition and net-zero targets by 2070. The government will also support Battery Energy Storage Systems with a capacity of 4,000 MWH through viability gap funding. The government has launched initiatives like the Faster Adoption of Manufacturing of Electric Vehicles Scheme–II (FAME-II) and the Production Linked Incentive Scheme (PLI) to support electric vehicle manufacturers [8]. The Budget allocated INR 51.72 billion (approximately $631 million) to the FAME-II scheme, an 80% increase from previous years, to subsidize and promote clean energy vehicles. Reduced custom duty on Lithium-ion batteries and excise duty exemptions on natural gas and biogas may lead to more foreign electric vehicles being imported to India [9-11]. Despite central and state government policies promoting electric vehicles (EVs) through incentives, infrastructure development, and research, India's EV adoption rate lags behind predictions and the global average. Analyzing consumer perception across different regions is essential to address this EV divide. India's electric vehicle market is set for significant growth, driven by supportive government policies, rising consumer awareness, and technological advancements. This transition towards sustainable transportation offers a great opportunity for local and international companies to invest in and contribute to the EV ecosystem. This study aims to bridge the gap by comparing consumer perceptions across different demographics. Understanding these differences will help develop more effective government policies and marketing strategies [12].

2. Research Purpose and Questions

This study aims to understand consumer perceptions and barriers to adopting electric vehicles (EVs) in an emerging economy, focusing on India [13]. It employs a comparative approach to analyze regional differences in perceptions and investigates how Indian customers integrate sustainability into their EV purchasing decisions across different demographics. The research results will help policymakers and auto manufacturers revise strategies to make the Indian transport sector more sustainable (Figure 1).

- How do customer perceptions influence their purchase intentions of electric vehicles (EVs) in India, and how does this influence vary across different settlement hierarchies?
- How do Indian customers incorporate sustainability considerations into their electric vehicle (EV) purchasing decisions, and how do these considerations vary across different demographics?

3. Overview of The EV Sales in India (SMEV 2024)



	17-18	18-19	19-20	20-21	21-22	22-23	23-24
E-2 Wheelers	2005	28007	26834	44803	252642	728054	944126
E-3 Wheelers	91970	116031	143051	90898	172543	401882	632485
E-4 Wheelers	1204	1885	2377	5154	18622	47499	90432
E-Buses	19	66	434	373	1194	1984	3693

Figure 1 EV Sales in India

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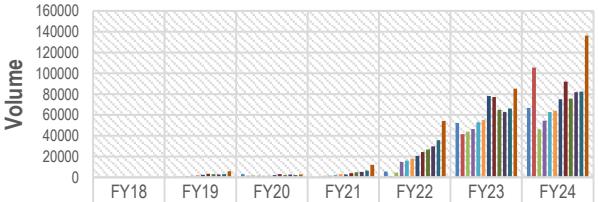
Table 1 EV Total Sales (Source: Society of Manufacturers of Electric Vehicles 2024)

Category	17-18	18-19	19-20	20-21	21-22	22-23	23-24
E-2 Wheelers	0.09%	1.38%	1.32%	2.21%	12.46%	35.92%	46.59%
E-3 Wheelers	5.57%	7.03%	8.67%	5.51%	10.46%	24.37%	38.35%
E-4 Wheelers	0.72%	1.12%	1.42%	3.08%	11.13%	28.41%	54.09%
E-Buses	0.24%	0.85%	5.59%	4.80%	15.38%	25.55%	47.57%

From the above table (1), sales of electric vehicles have seen significant growth across all categories [14-17]. From FY 20-21 to FY 21-22, the average growth rate increased from 3.90% to 12.36%. Further, from FY 21-22 to FY 23-24, the average growth rate surged to 46.65%. This indicates a strong willingness among people to purchase electric vehicles.

3.1.Electric 2-Wheelers Sales



	FY18	FY19	FY20	FY21	FY22	FY23	FY24
Apr	96	486	3079	85	5636	52389	66877
May	91	681	1668	558	1315	41727	105582
Jun	137	955	1758	1511	4751	44054	46106
Jul	116	1281	1568	1488	14692	46584	54614
Aug	99	1570	1507	2115	16099	53129	62767
Sep	109	2258	1558	3089	17959	55124	64077
Oct	160	2560	2136	2953	20704	78236	75144
Nov	214	3311	3147	4188	24503	77376	92018
Dec	189	3171	2235	4948	26862	65106	75855
Jan	176	2745	2942	5319	30041	62891	82018
Feb	156	3121	2353	6579	35759	66091	82508
Mar	462	5868	2883	11970	54320	85347	136560

Table 2 EV 4-Wheeler Sales (Source: SMEV)

As compared to month-on-month sales, the March months show significant sales growth (Table 2) [18].

4. Literature Review

This chapter provides the theoretical foundation for electric vehicle (EV) adoption, focusing on factors influencing purchase intentions and perceived risks. It covers the global context of EV adoption, dynamics in emerging economies, and the Technology Acceptance Model (TAM) for understanding consumer behavior. It also addresses psychological and practical barriers to EV adoption and introduces a conceptual framework for the study [19].

4.1. Worldwide Scenario of EV Adoption

Electric vehicles (EVs) are considered the future of automobiles and a solution to environmental hazards caused by fossil fuel emissions [20-23]. EV adoption offers numerous benefits, including reduced greenhouse gas emissions, improved safety, cost savings, lower maintenance, and a sustainable solution for pollution (Singh Patyal et al., 2021). Governments worldwide have implemented financial and non-financial incentives to promote EVs, such as tax credits, rebates, and access to high-occupancy vehicle lanes (Ghatikar et al., 2017; European Automobile Manufacturers Association, in press). As a result, the EV market has grown steadily, with global stock surpassing 10 million units in 2020, a 43% increase from 2019. Battery electric vehicles (BEVs) accounted for 67% of new registrations, with China leading in total EV ownership and Europe having the highest annual registrations (Das & Bhat, 2022) [24].

4.2.Type of Electric Vehicles and Technology

Electric vehicles (EVs) use electric motors for propulsion instead of traditional gasoline or diesel engines (Egbue & Long, 2012). There are four main types of EVs: battery electric vehicles (BEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs) (Larminie & Lowry, 2012) [25]. BEVs are powered entirely by rechargeable batteries, produce no direct emissions, and have lower operating costs, making them ideal for short commutes and city driving. HEVs combine a gasoline engine with an electric motor and battery,

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offering increased fuel efficiency and reduced emissions, suitable for long commutes and highway driving (Chau & Wong, 2002) (Figure 1 & 2).

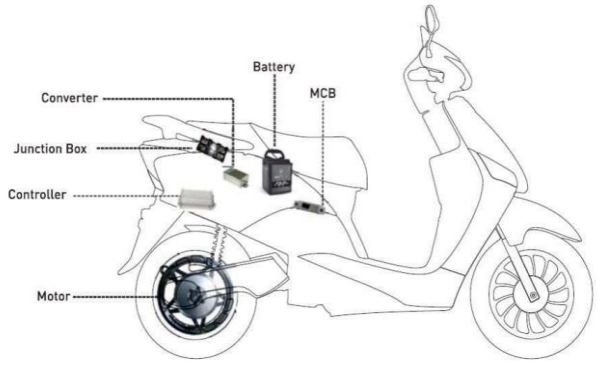

Figure 1 (Source: ICRA Research; *-Revised price assuming OEMs completely pass on the subsidy reduction to the consumer)

4.3.Enabling factors of EV adoption

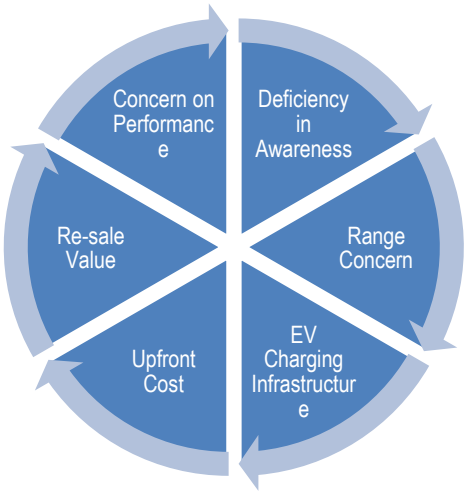

Figure 2 Enabling Factors of EV Adoption

4.3.1.Range Concern

One significant challenge for electric vehicle (EV) adoption is battery range and range anxiety. This anxiety arises from the fear of running out of power before reaching a destination or charging station (Rauh et al., 2015). Most EVs offer a shorter driving range compared to gasoline-powered vehicles, which can deter consumers. While many batteries electric vehicles (BEVs) can travel around 250 kilometers on a single charge (S. Goel et al., 2021), newer models are reaching closer to 400 kilometers (S. Goel et al., 2021). Studies show that BEVs with a range of more than 200 km are preferred by customers (Globisch et al., 2018; Singh Patyal et al., 2021).

4.3.2.EV Charging Infrastructure

India's charging infrastructure is still developing compared to the vast network of gas stations, which discourages potential EV buyers. Limited availability and long charging times create range anxiety, strongly linked to the availability of charging stations (Singh Patyal et al., 2021). The recharging process differs significantly from routine gas station refueling, which might not be clear to consumers considering EVs (Berkeley et al., 2018). Concerns about electricity supply reliability, power quality, and the grid's ability to handle increased EV charging loads can erode consumer confidence in EVs as a viable transportation option (Tarei et al., 2021).

4.3.3.Upfront cost

High upfront costs for electric vehicles (EVs) compared to internal combustion engines (ICE) vehicles (Lévay et al., 2017) are a significant barrier to sales. This is due to the high cost of lithium-ion batteries, research and development expenses, and lower production volumes. Consumers in emerging economies, with lower purchasing power (Meszaros et al., 2020), find it challenging to adopt EVs despite potential long-term fuel savings.

4.3.4.Re-Sale Value

Insufficient awareness about EV battery performance over time creates uncertainty in the resale market, discouraging potential buyers who worry about future value compared to gasoline vehicles. Despite being a well-established pre-owned market, EV resale values remain higher, adding to concerns over the high initial purchase price and potentially discouraging buyers (Berkeley et al., 2018).

4.3.5.Concern on Performance

Many studies highlight consumer attitudes towards electric vehicle performance as a significant barrier to adoption. Concerns include safety, reliability, and power, with limited battery power being a key issue. Consumers often perceive EVs as having lower top speeds and potentially compromised performance. Additionally, research suggests concerns about long-term battery degradation impacting

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performance (Goel et al. (2021).

4.3.6.Lack of Awareness

The electric vehicle (EV) market is still in its early stages, representing only a small portion of the overall vehicle market. This leads to a gap in consumer confidence and understanding of EVs as a viable option. Potential buyers often lack awareness of various EV-related aspects, including the latest technologies, available models, and specific advantages over alternative fuel vehicles. This confusion makes it difficult for consumers to assess the true value proposition of EVs (Singh Patyal et al., 2021).

5. Methodology

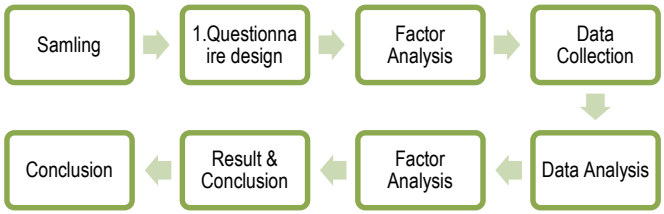

Figure 3 EVs Important Factors

This study uses a quantitative, cross-sectional survey design to examine consumer attitudes and behavior towards EVs in different demographic locations in India. Quantitative research allows for the collection and analysis of numerical data, providing insights into relationships between key variables across a diverse population. By including a large number of respondents, the study can gather various viewpoints and establish consistency and variations in different groups. The quantitative method is economical and can cover a vast number of respondents through surveys. This study aims to identify factors influencing Electric Vehicle (EV) adoption by consumers in India. Conducted from September to December 2023, it focused on a small population in Ahmedabad, Gujarat. A quantitative methodology was used, employing a survey instrument and Exploratory Factor Analysis. The data was examined for sampling adequacy using Bartlett's test for correlation adequacy and the KMO sampling adequacy test to ensure a good fit for factor analysis. In addition to closed-ended questions, the survey includes one open-ended question to capture any additional thoughts or concerns respondents may have about EV adoption. Respondents were also asked to rank their reasons for adopting EVs, enabling the analysis of the most important factors influencing their decision-making (Figure 3).

6. Results and Analysis

The quantitative analysis section examines responses from participants to understand customers' perceptions and barriers to electric vehicle adoption in India. The researcher used SPSS software to analyze the data, conducting various statistical tests such as frequency, descriptive statistics, correlation, and regression to present the findings.

6.1.Frequency Test

To measure participants' occurrence of responses for each survey question, a frequency test has been conducted to inform readers about the ratio of responses gathered from research participants

6.2.Demographic Analysis

The demographic evaluation is presented in the section below, prescribing information on the participants who were selected for the study (Table 3).

Table 3 Descriptive Statistics

S. No.	Demographic Factor		Percentage of responses
1	Gender	Male	56.4%
		Female	43.6%
2	Age group	25–34 years	62.8%
		35–44 years	33.1%
		45 years and above	4.1%
3	Occupation	Salaried employee	98.3%
		Owner of a firm	1.7%
4	Annual Income	At most 6 Lac	29.7%
		Above 6 Lac—less than 10 Lac	34.9%
		10 Lac—20 Lac	21.5%
		Above 20 Lac	13.9%
5	Number of cars owned	None	16.9%
		One	58.1%
		Two	22.7%
		Three or more	2.3%

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6.3.KMO and Bartlett's Test

The KMO-Bartlett's test measures sampling adequacy to check the suitability of the questionnaire data (Table 4). It provides information on classifying or grouping survey items, helping categorize them into interpretable factors that better explain the construct being investigated. It also explains how strongly an item is correlated with other items in the EFA correlation matrix (Burton & Mazerolle, Citation2011). The results of this study indicate a KMO value of 0.764, which is greater than the acceptable index of 0.5. Hence, the number of samples used is sufficient and accepted. This suggests that some pattern of correlations exists in the data (Williams et al., Citation2010). The level of significance obtained is 0.000, which is significant ($p<0.05$). This indicates that the correlation matrix is not an identity matrix, suggesting that clusters of items are correlated (Figure 3). Therefore, we can now proceed with the Exploratory Factor Analysis (EFA).

6.4.KMO and Bartlett's Test Result

Table 4 Communalities

	Initial	Extraction
Q1	1.000	.646
Q2	1.000	.718
Q3	1.000	.718
Q4	1.000	.697
Q5	1.000	.500
Q6	1.000	.631
Q7	1.000	.705
Q8	1.000	.810
Q9	1.000	.761
Q10	1.000	.324
Q11	1.000	.750
Q12	1.000	.587
Q13	1.000	.787
Q14	1.000	.701
Q15	1.000	.570
Q16	1.000	.365
Q17	1.000	.719
Q18	1.000	.793
Q19	1.000	.781
Q20	1.000	.752
Q21	1.000	.459
Q22	1.000	.723
Q23	1.000	.784
Q24	1.000	.593
Q25	1.000	.660
Q26	1.000	.565

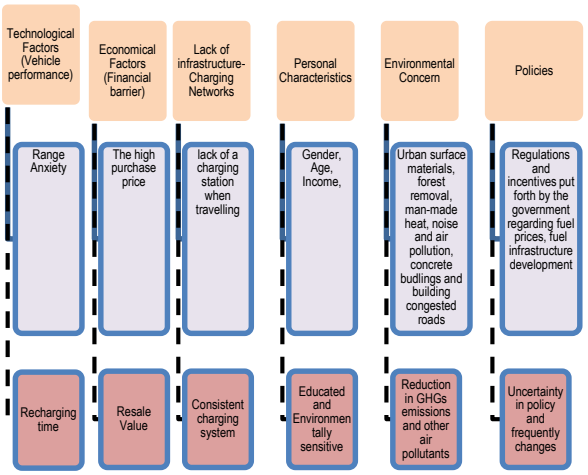

Figure 3 Factor Descriptions

7. Findings and Discussions of the Study

The findings of this study offer valuable insights for various stakeholders involved in the promotion and adoption of EVs in India:

- Policymakers should sustain and strengthen policy incentives for EV uptake, as there is a positive correlation between sustainability perceptions and EV buying intentions. Subsidies and other incentives should promote environmental enhancement. Additionally, increasing the availability of recharging options is necessary to address range anxiety and perceived risks, making EVs more viable for consumers.
- To the automotive industry, consumer preferences and external factors highlight the need for marketing to focus on more than just the functional features of electric vehicles (EVs). Effective communication should include competitive models, systematic information delivery of EV benefits, and addressing perceived risks through innovation and reliable service networks. These components are crucial for

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enhancing the adoption trend of EVs

- Consumer education is crucial for reducing perceived risks and increasing confidence in electric vehicles (EVs). Educating the public about specific attributes of EVs, such as reliability, affordability, and environmental benefits, can help alleviate concerns. Highlighting real-life benefits and showcasing successful EV owners can also positively influence public perception and encourage adoption.

Conclusion

India aims to transform its automobile industry towards e-mobility by addressing knowledge gaps and barriers in EV adoption. This project identifies six factors influencing consumers' intention to adopt electric vehicles in India: financial factors, vehicle performance factors, lack of charging infrastructure, environmental concern, societal influence, and awareness of electric vehicles. These factors align with findings by Noel et al. (2020), highlighting financial barriers, vehicle performance barriers, and lack of charging infrastructure as major factors in EV adoption in the Indian context.

Limitations of The Study

A limitation of this study is that it only included well-educated consumers, leaving out those with lower educational levels. The growth of EVs is expected to be faster in urban regions due to better infrastructure and higher per capita incomes, while rural areas remain unexplored. Further research is needed to understand EV barriers in rural India, which may differ from those in cities. However, one should bear in mind the limitations of this study in terms of the generalizability of results. The study primarily used survey data, which, while effective, is prone to response bias. Additionally, the sample size, though appropriate, was not large enough to fully encompass all aspects of the Indian market. Future studies could investigate EV owners' and potential consumers' attitudes using qualitative research methods, such as interviews.

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